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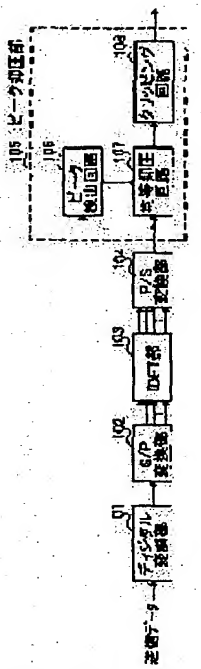
(54) MULTI-CARRIER TRANSMITTER

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a multi-carrier transmitter that reduces deterioration in an error rate characteristic due to distortion in a multi-carrier signal caused in the case of clipping and reduces deterioration in the error rate characteristic caused by decrease in a power level caused when the multi-carrier signals are uniformly suppressed so as to suppress a peak voltage.

SOLUTION: An IDFT section 103 applies OFDM modulation to transmission data to generate an OFDM signal, a peak detection circuit 106 decides the necessity of suppression of a generated multi-carrier signal, a uniform suppression circuit 107 uniformly suppresses the multi-carrier signals whose suppression is decided to be required and a clipping circuit 108 clips a peak voltage part so as to suppress a peak voltage.



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] Multi-carrier transmission equipment characterized by providing a generation means to carry out the multi-carrier modulation of the transmit data, and to generate a multi-carrier signal, and an oppression means to oppress only the peak voltage generating portion of the aforementioned multi-carrier signal while oppressing equally the whole multi-carrier signal which the peak generated.
[Claim 2] A suppression means is multi-carrier transmission equipment according to claim 1 characterized by connecting in series the peak voltage suppression circuit which oppresses only a peak voltage generating portion to a multi-carrier signal, and the equal suppression circuit which oppresses the whole multi-carrier signal equally.
[Claim 3] A suppression means is multi-carrier transmission equipment according to claim 1 or 2 characterized by oppressing only the peak voltage generating portion of a multi-carrier signal, and only a peak voltage generating portion oppressing the whole repressed multi-carrier signal equally.
[Claim 4] Base station equipment characterized by equipping either of a claim 1 to the claims 3 with the multi-carrier transmission equipment of a publication.
[Claim 5] The communication terminal characterized by equipping either of a claim 1 to the claims 3 with the multi-carrier transmission equipment of a publication.
[Claim 6] The multi-carrier transmission method which carries out the multi-carrier modulation of the transmit data, and is characterized by oppressing peak voltage by oppressing only the peak voltage generating portion of the aforementioned multi-carrier signal while oppressing equally the whole multi-carrier signal which judged the necessity of suppression of the multi-carrier signal which generated and generated the multi-carrier signal, and was judged as suppression being required.

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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the OFDM communication device using the OFDM (Orthogonal Frequency DivisionMultiplexing) modulation technique especially about the communication device using the multi-carrier modulation technique used for digital mobile communication system.
[0002]
[Description of the Prior Art] In performing radio with a high transmission speed, in connection with a symbol period becoming short, the influence of a multi-pass delay wave becomes large, and input-signal quality deteriorates. It is effective to perform a multi-carrier modulation to degradation of the input-signal quality by this multi-pass delay wave. The OFDM modulation technique which carries out a package modulation and carries out multiplex [of the subcarrier which is in two or more orthogonality relation using an IDFT (reverse discrete Fourier transform : Inverse Discrete Fourier Transform) circuit] in a multi-carrier modulation is typical.
[0003] In a multi-carrier modulation, when each subcarriers overlap, peak voltage may occur to a multi-carrier signal. In this case, when peak voltage exceeds the dynamic range of a latter analog circuit, since a non-line type distortion arises in a sending signal, the spurious radiation through which it passes out of band occurs, and there is a problem of giving interference to other users or other systems. Moreover, the mutual interference between each subcarrier occurs by nonlinear distortion, and there is also a problem that an error rate property deteriorates. To these problems, clipping which oppresses the peak voltage generating portion of a multi-carrier signal is known.
[0004] However, since clipping is un-****** signal transformation processing, the problem of generating the spurious radiation through which it passes out of band, or causing the mutual interference between each subcarrier and generating a digital error produces it.
[0005] "Multi-carrier signal-transmission equipment" is indicated by JP,11-74862,A as a means to solve this problem. Invention given in above-mentioned JP,11-74862,A detects the maximum of a multi-carrier signal for every symbol, and is oppressing peak voltage by oppressing equally the multi-carrier signal which corresponds according to the size also including parts other than the peak swing part of the symbol. under the present circumstances, suppression processing -- an amplitude -- constant twice -- although carried out by carrying out, since the mutual interference between the carriers which this constant twice operation is alignment operation, and are looked at by the technology using clipping is not produced, an error rate property does not deteriorate but there is also no spurious radiation through which it passes out of band
[0006]
[Problem(s) to be Solved by the Invention] However, with the technology which oppresses the above-mentioned conventional multi-carrier signal equally, in order to oppress the whole multi-carrier signal equally, the power level of a multi-carrier signal becomes low at the whole. Therefore, if this multi-carrier signal is amplified by the predetermined amplification factor and it transmits, since a signal-to-noise power ratio (SN ratio : Signal to Noise ratio) will decline by the receiving side, there is a problem that an error rate property deteriorates. Moreover, in order to prevent the fall of an SN ratio, when the amplifier which has a big amplification factor is used, enlargement of equipment is caused and there is a problem that equipment becomes expensive.
[0007] Degradation of the error rate property resulting from the fall of the power level produced in case this invention is made in view of this point, and degradation of the out-of-band spurious radiation resulting from nonlinear distortion started in case clipping of the multi-carrier signal is carried out, or an error rate property is reduced and a multi-carrier signal is oppressed equally is reduced, and it aims at offering the multi-carrier transmission equipment which can oppress peak voltage.
[0008]

[Means for Solving the Problem] The multi-carrier transmission equipment of this invention takes the composition possessing a generation means to carry out the multi-carrier modulation of the transmit data, and to generate a multi-carrier signal, and a suppression means to oppress only the peak voltage generating portion of the aforementioned multi-carrier signal while oppressing equally the whole multi-carrier signal which the peak generated.
[0009] As for the multi-carrier transmission equipment of this invention, in the above-mentioned composition, a suppression means takes the composition to which the peak voltage suppression circuit which oppresses only a peak voltage generating portion to a multi-carrier signal, and the equal suppression circuit which oppresses the whole multi-carrier signal equally were connected in series.
[0010] Degradation of the error rate property resulting from the fall of the power level produced in case according to these composition degradation of the spurious radiation resulting from nonlinear distortion started in case only the peak voltage generating portion of a multi-carrier signal is oppressed through which it passes out of band, or an error rate property is reduced and an OFDM signal is oppressed equally can be reduced.
[0011] Moreover, according to this composition, since only a peak voltage generating portion is oppressed, as compared with the case where only the conventional equal suppression is given, a peak-power pair mean power ratio can be made small. Therefore, transmitting amplification can be efficiently performed using the small amplifier of a dynamic range. Furthermore, since transmitting amplification can be performed using the small amplifier of a dynamic range, the miniaturization of amplifier can be attained and a price can be held down low.
[0012] The multi-carrier transmission equipment of this invention takes the composition in which a suppression means oppresses only the peak voltage generating portion of a multi-carrier signal, and only a peak voltage generating portion oppresses the whole repressed multi-carrier signal equally in the above-mentioned composition.
[0013] Degradation of the error rate property resulting from the fall of the power level produced in case according to this composition degradation of the error rate property resulting from distortion of the multi-carrier signal started in case only a peak voltage generating portion is oppressed is reduced and a multi-carrier signal is oppressed equally can be reduced. Moreover, according to this composition, as for clipping width of face, out-of-band spurious radiation or the amount of mutual interferences is beforehand decided to become below a predetermined value, and since equal suppression width of face becomes settled automatically so that the maximum of a clipping backward signal may turn into below a threshold, it can process easily.
[0014] The base station equipment of this invention takes the composition equipped with the above-mentioned multi-carrier transmission equipment. The base station equipment which can reduce degradation of the error rate property resulting from the fall of the power level produced in case according to this composition degradation of the spurious radiation resulting from nonlinear distortion started in case only the peak voltage generating portion of a multi-carrier signal is oppressed through which it passes out of band, or an error rate property is reduced and an OFDM signal is oppressed equally can be offered.
[0015] The communication terminal of this invention takes the composition equipped with the above-mentioned multi-carrier transmission equipment. The communication terminal which can reduce degradation of the spurious radiation resulting from the fall of the power level produced in case according to this composition degradation of the error rate property resulting from nonlinear distortion started in case only the peak voltage generating portion of a multi-carrier signal is oppressed is reduced and an OFDM signal is oppressed equally through which it passes out of band, or an error rate property can be offered.
[0016] The multi-carrier transmission method of this invention oppressed peak voltage by oppressing only the peak voltage generating portion of the aforementioned multi-carrier signal while oppressing equally the whole multi-carrier signal which carried out the multi-carrier modulation of the transmit data, judged the necessity of suppression of the multi-carrier signal which generated and generated the multi-carrier signal, and was judged as suppression being required.
[0017] Degradation of the error rate property resulting from the fall of the power level produced in case according to this method degradation of the spurious radiation resulting from nonlinear distortion started in case only the peak voltage generating portion of a multi-carrier signal is oppressed through which it passes out of band, or an error rate property is reduced and an OFDM signal is oppressed equally can be reduced.
[0018]
[Embodiments of the Invention] this invention person considered as the technology which oppresses the peak voltage generated to a multi-carrier signal, finds out that each degradation of the SN ratio by the equal suppression which is out-of-band spurious radiation, the un-****** distortion by clipping which caused error rate property degradation, and the cause of error rate property degradation is improvable paying attention to the both sides of clipping technology and the technology which oppresses the whole multi-carrier signal equally, and came to do this invention
[0019] That is, the main point of this invention is oppressing to the value of a request of peak voltage, and preventing

reduction of an SN ratio by carrying out clipping of the peak voltage generating portion while oppressing equally the multi-carrier signal which peak voltage has generated. Thereby, improvement can be simultaneously attained for reduction and the error rate property of out-of-band spurious radiation.

[0020] Hereafter, each operation gestalt of this invention is explained with reference to an accompanying drawing. (Gestalt 1 of operation) The gestalt 1 of operation explains the case where an OFDM modulation is used as an example of a multi-carrier modulation. In the multi-carrier transmission equipment of the gestalt of this operation, equal suppression of the OFDM signal is carried out first, and, subsequently clipping of the peak voltage generating portion is carried out.

[0021] Drawing 1 is the block diagram showing the composition of the multi-carrier transmission equipment concerning the gestalt 1 of operation of this invention. The multi-carrier transmission equipment shown in this drawing carries out digital modulation of the transmit data in the digital modulation section 101, is changed into a parallel signal by the S/P transducer 102, carries out IDFT (reverse discrete Fourier transform : Inverse Discrete Fourier Transform) processing in the IDFT section 103, is changed into an in-series signal (OFDM signal) by the P/S transducer 104, carries out suppression processing in the peak suppression section 105, and generates a sending signal.

[0022] The peak suppression section 105 possesses the peak-detection circuit 106, the equal suppression circuit 107, and the clipping circuit 108, and is constituted. If the OFDM signal which needs suppression from the P/S transducer 104 is inputted, the peak suppression section 105 oppresses the OFDM signal equally, and clipping of it will be carried out further and it will oppress peak voltage.

[0023] The peak-detection circuit 106 detects the maximum of the power of the OFDM signal outputted from the P/S transducer 104, and in order to judge whether the maximum needs suppression, it performs a threshold judging. Namely, the maximum (only henceforth "signal maximum") of the power of an OFDM signal is larger than the maximum permissible power of transmitting amplifier. Since suppression is required when causing the interference to an other station, and signal maximum is smaller than maximum permissible power, and suppression is unnecessary conversely when not causing the interference to an other station A threshold judging is performed by the threshold defined in consideration of the power value which causes the interference to the maximum permissible power and the other station of transmitting amplifier, and the necessity of suppression is judged. On these specifications, the maximum of the power of an OFDM signal when it is judged that suppression is needed is called peak voltage.

[0024] With reference to the threshold judging result in the peak-detection circuit 106, as for the equal suppression circuit 107, only equal suppression width of face oppresses an OFDM signal equally. That is, in judging that the peak-detection circuit 106 needs to oppress an OFDM signal, only a predetermined rate oppresses an OFDM signal equally by alignment processing, and the equal suppression circuit 107 outputs the oppressed OFDM signal to the clipping circuit 108. On the contrary, in judging that it is not necessary to oppress an OFDM signal from the judgment result of the peak-detection circuit 106, it outputs an OFDM signal to the clipping circuit 108 as it is. in addition -- oppressing equally -- the amplitude of not only a peak voltage generating portion but the whole OFDM signal -- constant twice -- it says oppressing an OFDM signal equally by carrying out The clipping circuit 108 performs clipping processing which oppresses the peak voltage generating portion of the OFDM signal outputted from the equal suppression circuit 107, and generates a sending signal.

[0025] Next, operation of the multi-carrier transmission equipment constituted as mentioned above is explained. In multi-carrier transmission equipment, digital modulation of the transmit data is carried out in the digital modulation section 101, and it is changed into a parallel signal by the S/P transducer 102, and IDFT processing is carried out in the IDFT section 103, it is changed into an in-series signal (OFDM signal) by the P/S transducer 104, suppression processing is carried out in the suppression section 105, and a sending signal is obtained. Quadrature modulation of the sending signal is carried out, and it is transmitted from an antenna.

[0026] Subsequently, operation of the peak suppression section 105 is explained. In the peak-detection circuit 106, the maximum of the power of the OFDM signal outputted from the P/S transducer 104 is detected, and in order to judge whether an OFDM signal needs suppression, the threshold judging of the signal maximum is carried out. In the equal suppression circuit 107, when it is judged that an OFDM signal needs suppression in the peak-detection circuit 106, an OFDM signal is oppressed equally and outputted to the clipping circuit 108. Since this processing oppressed equally is alignment processing, the configuration of a power wave over time becomes the same as the configuration of the power wave before suppression, and a non-line type distortion is not produced in the power wave of an OFDM signal. In the clipping circuit 108, clipping of the larger portion (peak voltage generating portion) than a threshold is carried out among the OFDM signals outputted from the equal suppression circuit 107. This clipping is carried out to the grade from which the out-of-band spurious radiation by nonlinear distortion becomes below an allowed value. In addition, when it is set in consideration of the power value which causes the interference to the maximum permissible power and the other station of transmitting amplifier and an OFDM signal is oppressed below to this threshold, this threshold can

suppress distortion of the signal in transmitting amplifier, and can also prevent the interference to an other station further.

[0027] Subsequently, the suppression processing to an OFDM signal is explained with reference to drawing 2 . Peak voltage has occurred to the OFDM signal S1 outputted from the P/S transducer 104. In the equal suppression circuit 107, only equal suppression width of face is oppressed equally, and this OFDM signal S1 turns into the OFDM signal S2. In case a signal is oppressed equally, power level declines, and this equal suppression width of face is beforehand set up in a system so that it may fit in the range in which degradation of this error rate property is permitted in a system or service in consideration of an error rate property deteriorating.

[0028] A peak voltage generating portion is oppressed only clipping width of face in the clipping circuit 108, and the OFDM signal S2 turns into the OFDM (clipping carried out) signal S3. When a non-line type distortion occurs to an OFDM signal by clipping, this clipping width of face is beforehand set up so that it may fit in the range in which this error rate property is permitted in a system or service in consideration of the radiation and the mutual interference through which it passes out of band happening, and an error rate property deteriorating.

[0029] Thereby, since the OFDM signal S3 takes the value below a threshold, the power of the OFDM signal S3 becomes smaller than the maximum permissible power of transmitting amplifier. Moreover, even if it changes an OFDM signal into a radio frequency and transmits, the interference to an other station is not caused.

[0030] The sum of equal suppression width of face and clipping width of face is equal to the difference of peak voltage and a threshold. Therefore, under predetermined peak voltage, if equal suppression width of face and clipping width of face will decrease in another side if one side is increased, and one side decreases, they have the relation whose another side increases. therefore, each equal suppression width of face which mentioned above equal suppression width of face and clipping width of face and clipping width of face -- an individual element -- in addition, a mutual relation is also taken into consideration and a suitable value is set up in a system or service

[0031] Thus, degradation of the error rate property resulting from the fall of the power level produced in case according to the gestalt of this operation degradation of the error rate property resulting from distortion of the OFDM signal which starts in the case of clipping by oppressing an OFDM signal so that peak voltage may take a value only with bigger clipping width of face than a threshold first, and subsequently carrying out clipping of the portion exceeding the threshold is reduced and an OFDM signal is oppressed equally can be reduced.

[0032] Moreover, since a peak voltage generating portion is oppressed by clipping, as compared with the case where only the conventional equal suppression is given, a peak-power pair mean power ratio (PAPR:Peak Powerto Average Ratio) can be made small. Therefore, transmitting amplification can be efficiently performed using the small amplifier of a dynamic range. Furthermore, since transmitting amplification can be performed using the small amplifier of a dynamic range, the miniaturization of amplifier can be attained and a price can be held down low.

[0033] (Gestalt 2 of operation) The gestalt of this operation is the modification of the gestalt 1 of operation, and after it carries out clipping to an OFDM signal, it is an operation gestalt which oppresses the OFDM signal after clipping equally. That is, it is different from the gestalt 1 of operation in that processing oppressed equally is performed after performing clipping to an OFDM signal. Hereafter, with reference to drawing 3 , the multi-carrier transmission equipment concerning the gestalt of this operation is explained. Drawing 3 is the block diagram showing the composition of the peak suppression section of the multi-carrier transmission equipment concerning the gestalt 2 of operation of this invention. In addition, in drawing 3 , since the composition of those other than the peak suppression section is the same as the multi-carrier transmission equipment concerning the gestalt 1 of operation, a publication is omitted.

[0034] The peak suppression section 201 possesses the peak-detection circuit 202, the clipping circuit 203, and the equal suppression circuit 204, and is constituted. The peak suppression section 201 oppresses an OFDM signal so that a non-line type distortion generated in transmitting amplifier may be reduced and the interference to an other station may be reduced.

[0035] The peak-detection circuit 202 detects the maximum of the power of the OFDM signal outputted from the P/S transducer 104, and in order to judge whether the maximum needs suppression, it performs a threshold judging. The clipping circuit 203 performs clipping processing only whose clipping width of face set up beforehand oppresses the peak voltage generating portion of the OFDM signal outputted from the P/S transducer 104 with reference to the threshold judging result in the peak-detection circuit 202, and outputs the OFDM signal which carried out clipping processing to the equal suppression circuit 204. Only equal suppression width of face oppresses equally the OFDM signal with which the equal suppression circuit 204 was outputted from the clipping circuit 203.

[0036] Next, operation of the peak suppression section 201 constituted as mentioned above is explained. In the peak-detection circuit 202, the maximum of the power of the OFDM signal outputted from the P/S transducer 104 is detected, and in order to judge whether an OFDM signal needs suppression, the threshold judging of the maximum is

carried out. In the clipping circuit 203, when judged with an OFDM signal needing suppression in the peak-detection circuit 202, the peak voltage generating portion of an OFDM signal is oppressed only for clipping width of face. In the equal suppression circuit 204, the OFDM signal outputted from the clipping circuit 203 is oppressed equally. Since this suppression processing is alignment processing performed to the whole OFDM signal for every fixed section, a non-line type distortion does not produce it to an OFDM signal.

[0037] Here, with reference to drawing 4 , the suppression processing to the OFDM signal in the gestalt of this operation is explained. Peak voltage has occurred in OFDM signal S1' outputted from the P/S transducer 104. In the clipping circuit 203, a peak voltage generating portion is oppressed only for the part of clipping width of face, and this OFDM signal S1' turns into OFDM (clipping carried out) signal S2'. In the equal suppression circuit 204, only equal suppression width of face is oppressed equally, and OFDM signal S2' turns into OFDM signal S3'. the equal suppression in this case -- an amplitude -- constant twice -- it is the alignment processing to perform by carrying out In addition, clipping width of face is beforehand set up so that out-of-band spurious radiation or the amount of mutual interferences may become below a predetermined value. On the other hand, in the equal suppression circuit 204, equal suppression width of face is set up so that it may become below the threshold by which the maximum of a clipping backward signal is set as the peak-detection circuit 202.

[0038] Thus, degradation of the error rate property resulting from the fall of the power level produced in case according to the gestalt of this operation degradation of the error rate property resulting from distortion of the OFDM signal which starts an OFDM signal in the case of clipping by only clipping width of face's carrying out clipping, and oppressing first so that maximum may subsequently become small rather than a threshold is reduced and an OFDM signal is oppressed equally can be reduced.

[0039] Moreover, since clipping width of face is beforehand set up so that out-of-band spurious radiation or the amount of mutual interferences may become below a predetermined value, and equal suppression width of face is set up so that the maximum of a clipping backward signal may turn into below a threshold, it can process easily.

[0040] Moreover, since a peak voltage generating portion is oppressed by clipping, as compared with the case where only the conventional equal suppression is given, a peak-power pair mean power ratio can be made small. Therefore, transmitting amplification can be efficiently performed using the small amplifier of a dynamic range. Furthermore, since transmitting amplification can be performed using the small amplifier of a dynamic range, the miniaturization of amplifier can be attained and a price can be held down low.

[0041] In addition, as the suppression method of a peak voltage generating portion, there is also the method of carrying out the multiplication of the weighting function other than clipping only around a peak voltage generating portion and peak voltage generating partial. Since out-of-band spurious radiation and a mutual interference can be further reduced rather than clipping by using a suitable weighting function, equal suppression width of face can be made still smaller, and it can transmit more efficiently.

[0042] In addition, in the gestalt of each above-mentioned implementation, although the OFDM modulation technique was held for the example of a multi-carrier modulation technique and was explained, this invention is not restricted to this but may use what multi-carrier modulation technique.

[0043]

[Effect of the Invention] Degradation of the error rate property resulting from the fall of the power level produced in case according to this invention degradation of the spurious radiation resulting from nonlinear distortion started in case only the peak voltage generating portion of a multi-carrier signal is oppressed through which it passes out of band, or an error rate property is reduced and an OFDM signal is oppressed equally, as explained above can be reduced.

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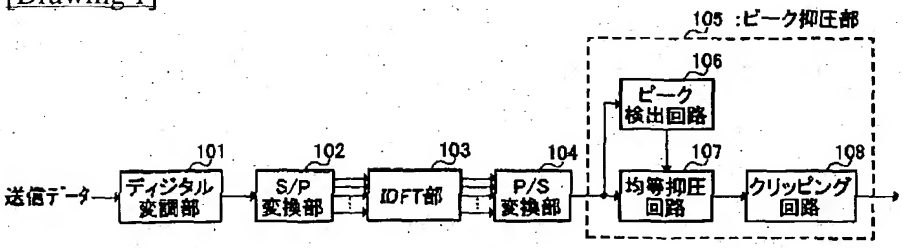
DRAWINGS

[Drawing 1]



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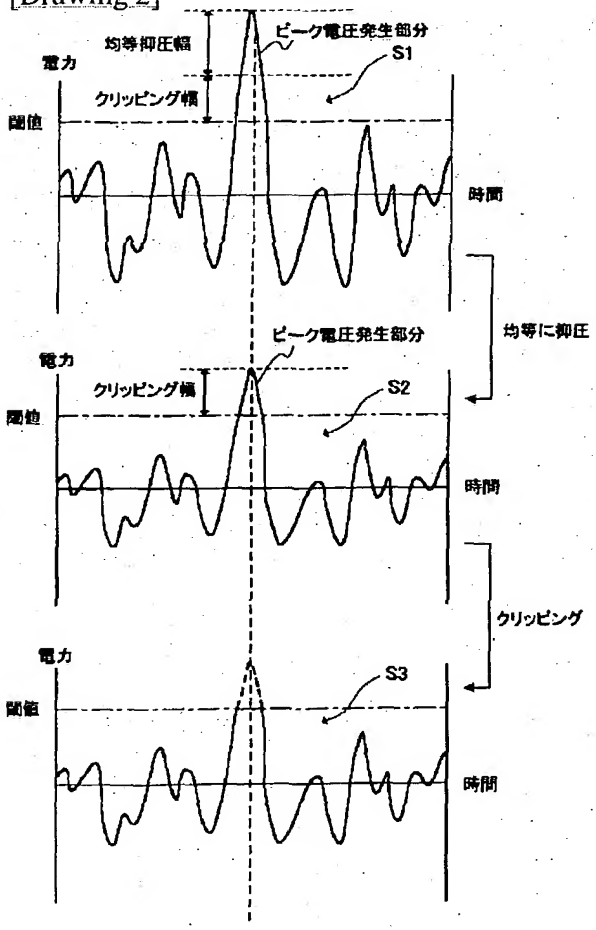

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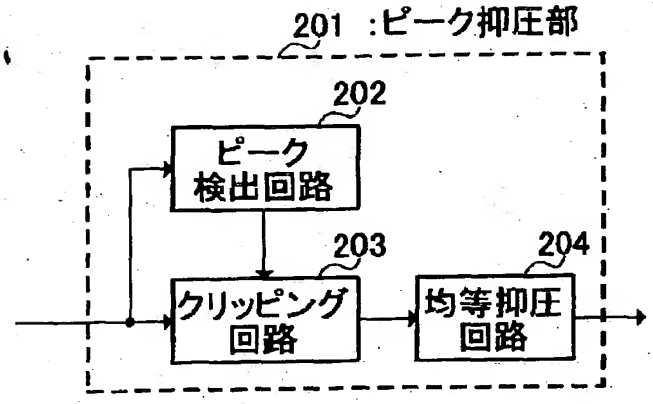
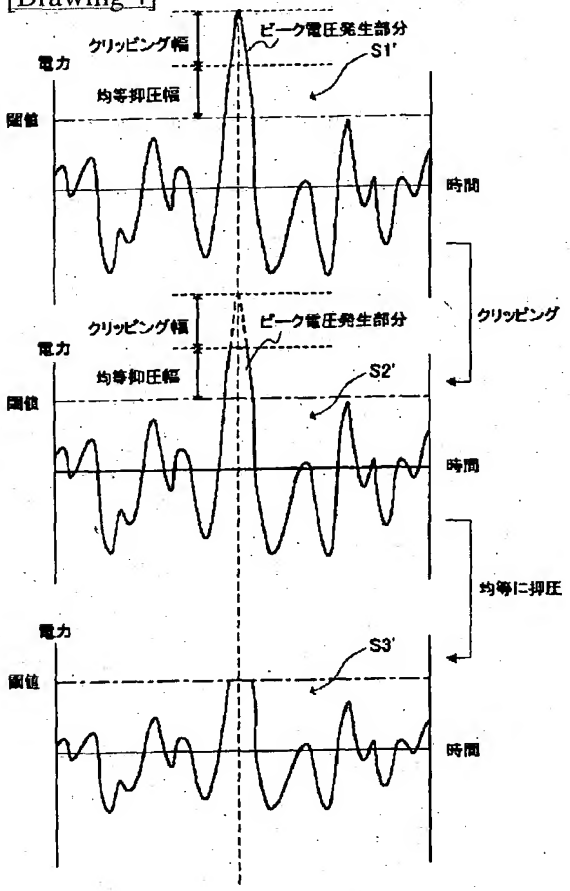


[Drawing 4]



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